A New Lccality and Faunal Assemblage of Fusulinids from the Limestone in the Area West of Ryoseki, Kochi Prefecture

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(With 1 plate, 6 tables)

INTRODUCTION AND ACKNOWLEDGEMENTS

In 1960, the writer published a detailed description on the geology and tectonics of the area northeast of Kochi City. In it, the Paleozoic rocks were classified in ascending order into the following eight formations, namely, Shinyashiki limestone, Miyanokuchi, Uekura, Shingai, Amatsubo, Sugita, Iwagai, and Yasuba formations. Since then he has been studying the fusulinids collected from the area as a continuation.

In this article the writer describes some fusulinids which be collected from the Shingai formation, at about lat. 33°37′16″ N. and long. 133°30′31″ E., in an area some 600 meters northeast of Yakyo, Uekura village, Nagaoka county, Kochi Prefecture. The fusulinids discriminated consist of *Schubertella kingi* Dunbar and Skinner, *Triticites simplex* (Schellwien), *Schwagerina* cfr. *munaniensis* Dunbar and Newell, *Schwagerina krotowi* (Schellwien), *Schwagerina* cfr. *stabilis* (Rauser-Cernoussova), and *Schwagerina magna* (Rosovskaya). Since no fusulinids have been known from the area the majority of the workers believed the area to belong to a part of the Yasuba formation from the general trend of the rocks. The fusulinids as now distinguished comprise an assemblage which indicate the Sakmarian or at best the early Artinskian in age. Considering the rock facies and fusulinid assemblage the strata concerned should be regarded as the Shingai formation, and as situated in a position much lower than the Yasuba formation which is represented by the so-called "*Yabeina-Lepidolina* assemblage". And from stratigraphical and paleontological evidence there is recognized a complicated anticlinal structure of the Paleozoic rocks in the area, and the data renders it possible to interpret the geohistorical relationships among the deposition of the Yasuba formation, inlier form of the Shingai formation in the midst of the Yasuba formation, and the covering of the Cretaceous rocks on both the Yasuba formation and the Shingai formation.

Here the writer thanks Professor Enzo Kon'no of the Institute of Geology and Paleontology, Tohoku University and Dr. Shoshiro Hanzawa, Professor Emeritus of the Tohoku University for their continued guidance and valuable suggestions during the course of the present work. Concerning the present work acknowledgements are due to Professor Kotora Hatai for his critical reading of the manuscript and to Dr. Masafumi Murata for his suggestions on the paleontology, both of the Tohoku University.

GENERAL CONSIDERATION

As already clarified by Kobayashi and Ijiri (1935), the lower Cretaceous rocks overlie on the subjacent Paleozoic formations with unconformity, being bordered by a peculiar shaped line of so-called the "Yakyo curve". The Paleozoic rocks making up the basis for the Cretaceous rocks, as recognized by the writer, consists of the Yasuba formation and the Shingai formation of different age. Suyari (1961) held that the Yasuba formation of lenticular shape is restricted in its distribution almost in east-west direction outside of the environs of the Cretaceous basin. Nevertheless, in the field, the writer found rather wide distribution of black silty mudstone, at least, in the cliffs and cuttings about 800 meters west of Yakyo to Ogura, which show superficial resemblance to the Mesozoic rocks, having low dips compared with those of the Shingai formation, and gentle structure, thus being sometimes becomes difficult to discriminate it from the latter. Consequently, those rocks under consideration should be referred to the Yasuba and not to the Shingai formation. On the other hand, the locality from where the writer collected the fusulinids to be described is situated on the western slopes of Kanigoe and may include the Shingai formation. From the facts stated above, it is considered that the Shingai formation occurs along the northern side of the Cretaceous basin in wedge-shaped distribution trending nearly in east-west direction and does not extend so far beyond the so-called "Yakyo curve" in contrast to the distribution of the Yasuba formation which seems to be rather extensive, at least, within the environs west of the Yakyo curve. In addition, from the results of the field survey, the writer detected that the Yasuba formation makes an undulatory structure expressed by anticlinal and synclinal structures, and the older Shingai formation is exposed in inlier form along the core of the anticline. From those facts stated, it is considered that rather intense folding took place by which the older Shingai formation became exposed along the anticlinal core in inlier form prior to the deposition of the Cretaceous rocks, although the synclinal axis of the Paleozoic rocks (Yasuba formation) seems to agree with those of the Cretaceous rocks. In the sedimentary basin formed as a result of Pre-Cretaceous disturbance, the deposition of the Cretaceous rocks might have been on both the Yasuba formation and Shingai formation. Therefore, from the geostructure, it is rather easy to comprehend that the geological structure of the Paleozoic formation differs from that of the Mesozoic.

As a result of investigation of the fusulinids obtained from the Shingai formation of the area mentioned above, the following eight species were discriminated among which six species will be described in another article.

Schubertella kingi Dunbar and Skinner
Triticites simplex (Schellwien)
Schwagerina cfr. *munaniensis* Dunbar and Newell
Schwagerina krotowi (Schellwien)
Schwagerina cfr. *stabilis* (Rauser-Cernoussova)
Schwagerina magna (Rosovskaya)
Pseudofusulina sp.
Paraschwagerina sp.

Schubertella kingi Dunbar and Skinner is widely distributed in the Wolfcampian formation of North America, and ranges from the equivalent formations of North America up to the zone of *Neoschwagerina* in Japan both, of the Akiyoshi limestones and the Ibukiyama limestones. *Schwagerina* cfr. *munaniensis* agrees well with *Schwagerina munaniensis* Dunbar and Newell described from the Yaurichambi, Central Andes, in many important bio-characters. There it occurred in association with *Pseudoschwagerina kozlowskii* Dunbar and Newell, and therefore, should be referred to the Sakmarian or the Wolfcampian in age. *Schwagerina stabilis* (Rauser-Cernoussova) was collected from the Second and Third Complex in Samara Bend and from the Yayamadake limestone, where it is associated with *Pseudofusulina santyuensis* Huzimoto, *Pseudofusulina* sp., *Rugosofusulina pristima* Kanmera, *Triticites* sp., and *Nankinella kotakiensis* (Huzimoto and Kawada); it is referred to the upper part of the *Pseudoschwagerina* zone. *Schwagerina magna* (Rosovskaya) is closely allied with *Triticites magnus* Rosovskaya from the zone of *Pseudofusulina sokensis* (C_3^2) of the Gorki region, Russia. On the other hand, *Paraschwagerina* which was obtained from the studied area has been known to be distributed widely, ranging from the Wolfcampian to Artinskian in North America. From the reasons mentioned above, the Shingai formation under consideration should be referred to the Sakmarian of Russia or the Wolfcampian of North America and possibly up to the lower Artinskian in age.

SYSTEMATIC DESCRIPTION

Family Fusulinidae Möller, 1878
Subfamily Schubertellinae Skinner, 1931
Genus ***Schubertella*** Staff and Wedekind, 1910
Schubertella kingi Dunbar and Skinner
Pl. 29, Fig. 3.

Schubertella kingi Dunbar and Skinner, 1937, p. 610, 611, pl. 45, figs. 10–15; Thompson and Wheeler, 1946, p. 24, 25, pl. 8, figs. 6–10 ; Thompson and Hazzard, 1946, p. 40, 41, pl. 10, figs. 1–9; Thompson, 1954, p. 33, 34, pl. 5, figs. 11–42, pl. 7, figs. 11–12; Igo, 1957, p. 192–194, pl. 4, figs. 9–15; Kobayashi, 1957, p. 262, 263, pl. 1, figs. 6–8; Toriyama, 1958, p. 73–75, pl. 7, figs. 1–8.

Shell minute in size, elongate fusiform, with almost straight axis of coiling, almost straight median portion, convex lateral slopes, and bluntly rounded poles. Shell of five volutions 0.90 mm in half length and 0.32 mm in half width, giving form ratio of 2.18. Inner one or a half and one volution almost spherical. Coiling axis becomes extended rather rapidly from subsequent outer volution, remaining almost in same axial profile to maturity.

Proloculus small, almost spherical, with an outside diameter of 60 microns. Shell expands slowly outwards throughout. Radius vector 60, 90, 140, 200, and 320 microns, respectively. Chamber height almost same throughout axial profile except in polar extremities where it attains maximum height throughout except in inner one or two juvenile volutions.

Spirotheca thin, consists of a thin tectum and thicker lower transparent layer in outer volution, and structureless, consists apparently of single thin layer in inner two or so volutions. Alveolar structure unseen throughout. Thickness of spirotheca of first to fifth volution of a axial section 10, 8, 18, 23, and 40 microns, respectively. Proloculus wall thin, structureless, consisting of a single homogeneous thin layer.

Septa feebly fluted in axial region of outer three volutions, but remaining portion of shell essentially unfluted throughout. Septal counts unknown.

Tunnel distinct in second to third volution, but indiscernible in remaining volutions. Tunnel angles rather wide, 53 degrees in third volution. Chomata develops in second to third volution, low and wide, slightly asymmetrical, with a steeper tunnel side and more gentle polewards slopes. No phrenotheca nor axial fillings throughout.

Table 1. Measurements of *Schubertella kingi* Dunbar and Skinner.

specimen	prol.	radius vector					H.L.	H.W.	F.R.
		1	2	3	4	5			
191–14–e	0.06	0.06	0.09	0.14	0.20	0.32	0.90	0.32	2.91
	thickness of spirotheca								
	.007	.010	.008	.018	.023	.040			
	tunnel angles								
				53					

Remarks: – This species is most widely distributed in both, the American Wolfcampian rocks and Japanese equivalents or more higher horizons up to the zone of *Neoschwagerina*, including the Ibukiyama limestone and the Akiyoshi limestone. In general, the present species has been reported from various regions distributed rather widely, both stratigraphically and geographically. *Schubertella kingi* Dunbar and Skinner was designated for the first time in 1937, by Dunbar and Skinner for the materials obtained from the basal beds of the Permian in the Hueco Mountains and the Sierra Diablo Plateau, in addition to the Wolfcampian formations in the Glass Mountains and the Cottonwood limestone of Kansas and Nebraska and Coleman limestone of north-central Texas. The present specimen somewhat differs from the type specimens in having somewhat more rapid expansion rate of the shell from the third volution to maturity, slightly less development of the chomata, larger shell size, and thicker spirotheca of the former, although the pronounced biocharacters of both agree well with one another. Afterwards, Thompson (1954) has reexamined the species under consideration, and concluded that the species comprises two groups one of slender form and the other of rather thick form, from the Waldrip beds of Texas, and Cottonwood limestone and Florena shale of Kansas and the Coleman Junction limestone of Texas. Rather great individual variation of these two groups recongnized within each group make it difficult to separate them specifically from one another. Therefore, the writer is inclined to consider that the species includes considerable variations in the shell size as well as in their shell forms. The specimen described for the first time by Dunbar and Skinner may be situated in about an intermediate position between the two extremities. The majority of the specimens described from the Akiyoshi limestone and Fukuji district may belong to the less slender form group, and part of the specimens described from the Ibukiyama limestone and the present specimen may belong to the other group of the two.
Repository: – IGPS cat. no. 78833, loc. no. 191–14–c.

Subfamily Schwagerininae Dunbar and Henbest, 1930
Genus ***Triticites*** Girty, 1904
Triticites simplex (Schellwien)
Pl. 29, Figs. 1–2.

Fusulina simplex Schellwien, 1908, p. 179–182, pl. 18, figs. 4–6, 12.
Schellwienia simplex Lee, 1927, p. 40–42, pl. 5, figs. 6–11, 13.
Triticites simplex Chen, 1934, p. 24, 25, pl. 1, figs. 16, 17, 21; Huzimoto, 1936, p. 48, 49, pl. 4, figs. 1–6; Huzimoto, 1938, p. 119, 120, pl. 8, figs. 9–17; Rauser-Cernoussova, 1938, p. 111, 112, pl. 3, figs. 7–8 ; Toriyama, 1958, p. 95–99, pl. 9, figs. 8–25.
Triticites (Triticites) shikhanensis shikhanensis Rosovskaya, 1950, p. 27, pl. 6, figs. 1–2.

Shell moderate in size, somewhat elongate fusiform, with almost straight coiling axis, slightly inflated median portion, convex lateral slopes, bluntly or rather well rounded poles. Mature specimens of five volutions 1.60 mm in half length and 0.80 mm in half width, giving form ratio of 2.0 Inner one or two volutions almost spherical, from third volution coiling axis expands rather rapidly, from which to maturity shell remains in nearly same axial profile.

Proloculus small, spherical with outside diameter of 140 to 180 microns, averaging 160 microns in two specimens. Shell rather tightly coiled in inner two or three volutions, but expands at slightly more rapid but uniform rate from subsequent outer volution to maturity. Average radius vector of first to fifth volution in two specimens 130, 230, 380, 565, and 800 microns, respectively. Chamber height almost same throughout shell length in inner two volutions, but increasing in height polewards from median portion in subsequent outer volutions.

Spirotheca rather thick for shell size, and consists of a tectum and a fine alveolar keriotheca, of which both indiscernible in inner two volutions by secondary mineralization. Six to eight alveoli seen in 100 microns distance of spirotheca in outermost volution. Average thickness of first to fifth volution in two specimens 15, 27, 53, and 90 microns, respectively. Proloculus wall thin, 5 microns thick, apparently structureless, consisting of a single homogeneous dense layer.

Septa rather thick, widely spaced, and fluted rather widely; in inner three volutions almost unfluted except in polar extremities, from fourth volution to maturity septal fluting rather intense, forming wide and low septal loops reaching almost to a half of chamber height, and in polar region of outer few volutions it comes to form rather simple networks. Septal counts unknown.

Tunnel low and rather narrow in inner two to three volutions, from subsequent outer volution to maturity becomes wider. Average tunnel angles of first to fourth volution in two specimens 28, 37, 42, and 43 degrees, respectively. Chomata develops rather distinctly except in outermost one volution; almost asymmetrical with considerably steep slopes. No axial fillings nor phrenotheca throughout.

Table 2. Measurements (in mm) of *Triticites simplex* (Schellwien).

specimen	prol.	radius vector					H.L.	H.W.	F.R.
		1	2	3	4	5			
191- 3-c	0.140	0.10	0.18	0.28	0.46	0.80	1.60?	0.80	2.00
191-11-c	0.180	0.16	0.28	0.47	0.67		1.30	0.67	1.94
	thickness of spirotheca								
191- 3-c	.005	.010	.020	.035	.045	.090			
191-11-c	?	.020	.034	.070	.060				
	tunnel angles								
191- 3-c		24	31	33	50				
191-11-c		32	42	50	35?				

Remarks : – The present specimen has rather small shell size compared with those described up to date from various regions. But the important bio-characters found in the present specimens well agree therewith. The present specimens and *Triticites simplex* described up to the present including Schellwien's holotype specimens well agree with *Triticites shikhanensis shikhanensis* Rosovskaya described from the zone of *Triticites montiparus* of Bashkir, U. S. S. R., in pronounced bio-characters, therefore, the writer treats them as synonyms.

The present specimen has somewhat feebler septal flutings than those described from Japan (Akiyoshi limestone and Kwanto Massif) but almost agrees with those of Schellwien's type specimens.

Repository :– IGPS cat. no. 78831, 78832, Sample no. 191–3–c, 191–11–c.

Genus ***Schwagerina*** Möller, 1877
Schwagerina cfr. ***munaniensis*** Dunbar and Newell
Pl. 29, Fig. 11.

Compared with : –

Schwagerina munaniensis Dunbar and Newell, 1946, p. 467–468, pl. 11, figs. 7–13.

Shell ovoid in shape, with almost straight coiling axis, much inflated median portion, convex lateral slopes, and rather broadly rounded ends. Specimen of a half and three volutions 0.86 mm in half length and 0.48 mm in half width, giving form ratio of 1.8. Inner one or two volutions almost subspherical, from subsequent outer volution to maturity coiling axis extended rapidly, remaining almost same axial profile.

Proloculus small in size, spherical, with an outside diameter of 180 microns. Shell rather tightly coiled in inner two volutions, but expands at more rapid but uniform rate from subsequent outer volution to maturity. Radius vectors of first to third volution for a axial section 150, 260, and 480 microns, respectively. Chamber height almost same in median two-thirds of shell length, but increasing in height slightly polewards.

Spirotheca moderately thick, consists of a thin tectum and rather thick alveolar keriotheca which apparently medium in coarseness; its structure indiscernible in inner few volutions but distinct in outermost two volutions. Thickness of spirotheca of first to third volution 25, 40, and 50 microns, respectively. Proloculus wall thin, 20 microns thick, structureless, consisting of a single thin homogeneous dark layer.

Septa rather widely spaced, highly but widely fluted throughout shell length in outer few volutions; reaching three-quarters of chamber height to almost tops of chamber, but almost straight except in polar extremities for inner few volutions. Septal counts unknown.

Tunnel rather wide and high with irregular path throughout. Tunnel angles of first to third volutions 18, 21, and 26 degrees, respectively. Chomata develops in rudimentary form throughout except in outermost volution; narrow and feeble, asymmetrical, with steep or overhanging tunnel sides and more gentle poleward slopes. No axial fillings nor phrenotheca throughout.

Table 3. Measurements (in mm) of *Schwagerina* cfr. *munaniensis* Dunbar and Newell.

specimen	prol.	radius vector			H.L.	H.W.	F.R.
		1	2	3			
191–13–c	0.18	0.15	0.26	0.48	0.86	0.48	1.8
	thickness of wall						
	.010	.025	.040	.050			
	tunnel angles						
		18	21	26			

Remarks: – Only one rather fragmental specimen was examined. Consequently, the detailed bio-characters of the present specimen remain undefinite.

The species is closely similar to *Schwagerina munaniensis* Dunbar and Newell described from Munani, Peru, in many important bio-characters. The only difference between them is that the present species has less volutions, and consequently much smaller shell size, although the radius vectors of the corresponding volutions well agree with one another.

The specimen obtained from Shikoku is also allied to *Pseudofusulina andina* Roberts from the Copacabana group of Huanta, Peru, but differs from the latter in having less volutions and exceedingly feebler septal flutings in the inner few volutions of the former.

The species resembles somewhat also *Schwagerina primigena* Nogami from the Atetsu Plateau, but differs from the latter, in having thinner spirotheca of the corresponding volutions and much rapid expansion rate of the shell in the earlier few volutions of the former.

Repository: – IGPS cat. no. 98838, loc. no. 191–13–a.

Schwagerina krotowi (Schellwien)
Pl. 29, Figs. 6–10.

Fusulina krotowi Schellwien, 1908, p. 190–192, pl. 20, figs. 1–10.
Schellwienia krotowi Ozawa, 1925, p. 27, 28, pl. 7, figs. 5, 6.
Pseudofusulina krotowi Huzimoto, 1936, p. 82–84, pl. 15, figs. 1–5, 9–15; Rauser-Cernoussova, 1938, p. 143, 144, pl. 9, figs. 1, 2.
Schwagerina krotowi Toriyama, 1958, p. 134–138, pl. 15, figs. 8–19.

Shell inflated fusiform, with almost straight axis of coiling, somewhat inflated median portion, convex to almost straight lateral slopes, and broadly pointed poles. Mature specimen of six to seven volutions 4.5 to 5.9 mm long and 2.5 to 3.2 mm wide, giving form ratio of about 1.8. Inner one volution almost spherical shape, and in second volution, axis of coiling extends rather rapidly, from which to fourth or third volution shell remains nearly same axial profile. In subsequent outer few volutions, it becomes more inflated fusiform again.

Proloculus rather small in size, almost spherical, with outside diameter of 190 to 280 microns, in five specimens, averaging 218 microns. Shell relatively tightly coiled in inner two or three volutions, but expands more rapidly but uniformly from subsequent outer volution to maturity. Average radius vector of first to seventh volution 170, 252, 385, 608, 918, 1,330, and 1,360 microns, respectively. Height of chambers almost same throughout shell length except in polar extremities of some volutions where attains maximum in height.

Spirotheca rather thick for shell size, consists of a tectum and a rather coarse alveolar keriotheca, sometimes upper transparent layer occurs; occasionally rather obscure keriothecal structure seen. Average thickness of spirotheca from first to maturity for four specimens 14, 31, 43, 70, 85, 115, and 100 microns, respectively. Four to five alveoli in 100 microns in outermost volution; not recognized in first one or two volutions. Proloculus wall thin, averaging 12 microns thick for three specimens, seemingly structureless, consisting of a tectum-like single layer.

Septa rather widely spaced, fluted narrowly and moderately in height, reaching about a half to two-thirds of height of chambers throughout shell length; rather thick for shell size. Septal counts of each volution unknown.

Tunnel low, moderate in width, with rather straight path. Average tunnel angles of first to sixth volution for four specimens 23, 25, 25 ,23, 24, and 24 degrees, respectively. Chomata develops in rudimentary form, irregular shape, asymmetrical with steep or overhanging tunnel side and more gentle poleward slopes in inner three to four volutions; those of subsequent outer volutions becomes almost symmetrical shape. No axial fillings throughout. Phrenotheca develops in some part of shell except in inner few volutions.

Remarks: – Two groups of specimens with some slight differences from one another are here included in the species. One is closely allied with Schellwien's type specimens in the pronounced bio-characters; the other has more elongate shell form in the juvenile few volutions and somewhat less strongly fluted septa.

Schwagerina krotowi (Schellwien) has been described from the Akiyoshi limestone by Ozawa and Toriyama, and from the Kwanto massif by Huzimoto. All of them have regular septal flutings, and circular septal loops throughout the shell except for Ozawa's specimens. Concerning the shell form of the juvenile few volutions and the mode of the septal fluting, the majority of the present specimens agree well with those of Ozawa,

Table 4. Measurements (in mm) of *Schwagerina krotowi* (Schellwien).

specimen	prol.	radius vector							leng.	width	F.R.
		1	2	3	4	5	6	7			
191-4 -b	0.20	0.16	0.24	0.38	0.64	1.00	1.38		2.25 (x2)	2.50	1.8
191-2 -a	0.19	0.16	0.21	0.30	0.46	0.67	1.00	1.36	1.80	1.06	1.7
191-2 -b	0.20	0.16	0.24	0.36	0.55	0.86	1.28		2.30	1.15	2.0
191-12-a	0.28	0.20	0.32	0.50	0.78	1.14	1.66		2.95 (x2)	1.60 (x2)	1.8
	thickness of spirotheca										
191-4 -b	.010	.010	.030	.040	.080	.100	.120				
191-2 -a	.015	.020	.030	.024	.050	.060	.100	.100			
191-2 -b	.010	.010	.040	.050	.070	.080	.100				
191-12-b	?	.015	.025	.055	.080	.100	.140				
	tunnel angles										
191-4 -b		29	29	38	28	30					
191-2 -a		21	25	19	20	26	24				
191-2 -b		22	23	22	20	22					
191-12-a		21	21	21	21	18					

but not with those of other's. Moreover, the foreign specimens differ from the Japanese ones in the mode of the septal fluting except for Ozawa's specimens. The type specimens of Schellwien have more irregular but highly fluted septa throughout and more globular shell form of the juvenile volutions compared with the second group of the present specimens under consideration. Separation of the two groups is difficult because of the intermediate forms. Therefore, it seems that all of the specimens should be referred to the same species.

The present species is somewhat allied to *Schwagerina munaniensis* Dunbar and Newell in the mode of the septal fluting and evolutionary stage, but differs from the latter in having more thick shell form, more rapid expansion rate of the shell, less tunnel angles, and essentially more convex lateral slopes throughout the shell of the former. *Schwagerina munaniensis* Dunbar and Newell occurred in association with *Pseudoschwagerina kozlowskii* Dunbar and Newell at Yaurichambi of the Central Andes.

The present species is similar to some specimens of *Triticites* (*Jigulites*) *magnus* Rosovskaya, but differs from the latter in having no axial filling, more thick form, much inflated median part, essentially convex lateral slopes, and much smaller shell of the former.

Repository: - IGPS cat. no. 78835, 78836, 78836, 78836, 78837, loc. no. 191-4-b, 191-2-b, 191-2-a, 191-2-c, 191-12-a.

Schwagerina cfr. ***stabilis*** (Rauser-Cernoussova)
Pl. 29, Figs. 4-5.

Compared with:

Rugosofusulina stabilis Rauser-Cernoussova, 1937, pl. 1, fig. 7.
Pseudofusulina stabilis Rauser-Cernoussova, 1938, p. 158, figs. 8, 9, pl. 8, fig. 3.
Schwagerina stabilis Kanmera, p. 191-193, pl. 31, figs. 1-12.

Shell rather minute in size, rather typical fusiform with convex lateral slopes, bluntly pointed poles, almost straight axis of coiling. Mature specimen of a half and four volutions 1.02 mm in half length and 0.54 mm in half width, giving form ratio of 1.88. Inner one volution subspherical in shape, coiling axis becomes extended rapidly in second volution, from which to maturity shell remains in nearly same axial profile.

Proloculus rather small in size for shell size, spherical with an outside diameter of 130 to 210 microns, averaging 170 microns in two specimens. Shell coils tightly throughout, but somewhat more loosely outwards. Average radius vectors of first to fourth volution for two specimens 130, 240, 390, and 540 microns, respectively. Height of chambers almost same throughout shell length except in polar extremities of second volution.

Spirotheca moderate thick, consists of a tectum and a fine alveolar keriotheca in outer volution, but almost indiscernible in inner few volutions where it seems to be a single homogeneous dark layer. Average thickness of spirotheca of first to fourth volution for two specimens 17, 23, 45, and 65 microns, respectively. Proloculus wall thin, 8 to 20 microns, averaging 14 microns for two specimens, and seemingly structureless; consisting of a single homogeneous layer.

Septa moderately spaced, moderate in fluting, rather widely and slowly, reaching almost two-thirds of chamber height, composing septal loops for larger parts of shell, but more strongly, reaching almost to tops of chambers, composing networks in polar regions. Septal counts of first to third volution in a sagittal section 9, 15, and 20, respectively.

Tunnel low, moderate in width throughout shell with almost straight path. Tunnel angles of first to third volution of an axial section 29, 29, and 24 degrees, respectively. Chomata develops weakly and rudimentary form throughout shell; rather asymmetrical with steep tunnel sides and gentle poleward slopes, but in third volution it becomes almost club-like shape curved sharply inwards. Axial fillings develop broadly. No phrenotheca.

Table 5. Measurements (in mm) of *Schwagerina* cfr. *stabilis* (Rauser-Cernoussova).

specimen	prol.	radius vector				H.L.	H.W.	F.R.
		1	2	3	4			
191-5 -a	0.13	0.10	0.20	0.34	0.54	1.02	0.54	1.88
191-14-c	0.21	0.16	0.28	0.44				
	thickness of spirotheca							
191-5 -a	.008	.013	.020	.045	.065			
191-14-c	.020	.020	.025	.045				
	number of septa							
191-14-c		9	15	20				
	tunnel angles							
191-5 -a		29	29	24	?			

Remarks: – The present species is somewhat similar to *Schwagerina jewetti* Thompson described from the Cottonwood limestone of Kansas, but differs from the latter in having much thicker form, less strong septal fluting, and more or less thicker spirotheca of the former.

The present species also resembles "*Pseudofusulina*" *stabilis* Rauser-Cernoussova described from the Second and Third Complex in Samara Bend of Russia in many bio-characters. Slight difference between them may be that the former is of smaller form with less volutions and slower shell expansion rate throughout in spite of having rapid expansion rate from the second volution to the maturity of the latter.

The present species differs from Kanmera's specimens from the Yayamadake limestone in having less volutions and much smaller size of the shell, and somewhat less number of septa for corresponding volutions.

The species was originally referred to *Rugosofusulina* and later to *Pseudofusulina*, but the writer is inclined to consider that it should be referred to *Schwagerina* from the same reasons as stated by Kanmera (1958).

Repository : – IGPS coll. cat. no. 78834, 78833, loc. no. 191–5–a, 191–14–c.

Schwagerina magna (Rosovskaya)

Pl. 29, Figs. 12–13.

Triticites (*Jigulites*)*magnus* Rosovskaya, 1950, p. 40–41, pl. 9, figs. 4–7.

Shell inflated fusiform or subrhomboidal in shape, with almost straight coiling axis, much inflated median portion, almost straight to somewhat convex lateral slopes, bluntly pointed poles. Mature specimen of six volutions 3.35 mm in half length and 1.60 mm in half width, giving form ratio of 2.09. Inner one or two volutions almost spherical in shape, and their coiling axis becomes expanded rather rapidly from third volution, from which to maturity remaining nearly in same axial profile.

Proloculus moderate in size for shell size, with diameter of 200 to 240 microns, averaging 220 microns for two specimens. Shell relatively tightly coiled in inner two volutions, but expands at slightly rapidly but uniformly from third volution to maturity. Average radius vectors of first to sixth volution in two specimens 195, 370, 590, 1,005, 1,250, and 1,660 microns, respectively. Chamber height minimum in central portion, increasing in height gradually polewards.

Spirotheca rather thick for shell size, consists of a rather coarse alveolar keriotheca and a thin structureless tectum; five alveoli seen in a distance 100 microns of spirotheca of fifth volution. Both of which indiscernible in inner one or a half and one volutions by secondary mineralization. Average thickness of spirotheca of first to sixth volution in two specimens 30, 50, 85, 117, 140, and 120 microns, respectively. Proloculus wall thin, structureless, consisting of a single homogeneous dense layer.

Septa rather thin for shell size, widely spaced, and fluted regularly, widely but highly in major parts of shell; reaching to two-thirds of chamber height in a half median part of axial profile, and to almost tops of chambers in remaining parts. Septal counts of first to fourth volution in a sagittal section 11, 19, 21, and 29 ?, respectively.

Tunnel wide and rather high throughout with slightly irregular path. Tunnel angles of first to fifth volution in an axial section 18, 25, 31, 36, and 27 degrees, respectively. Chomata develops rather distinctly almost throughout except for outermost volution where it becomes indiscernible; rather high and narrow knoll-shaped, almost symmetrical with steep slopes, reaching to two-thirds or almost to tops of chambers. Proper axial fillings develop along coiling axis, and weak phrenotheca seen in some part of shell. Moderate rugosity of spirotheca seen in some part of lateral slopes.

Remarks : – The present specimens well agree with *Triticites* (*Jigulites*) *magnus* Rosovskaya described from the zone of *Pseudofusulina sokensis* (C_3^2) of the Gorki region, Russia, in many important bio-characters, although only one slightly tangential section is at hand, and rather incomplete for study of the specimen in detail. Slight difference between them is found in having somewhat thicker spirotheca in the penultimate volution and weaker axial filling of the present specimen.

Schwagerina magnus (Rosovskaya) from Shikoku resembles also *Triticites stuckenbergi* Rauser-Cernoussova from the Samara Bend, Russia, but differs from the latter in having

Table 6. Measurements (in mm) of *Schwagerina magna* (Rosovskaya)

specimen	prol.	radius vector						H.L.	H.W.	F.R.
		1	2	3	4	5	6			
191-11-a	0.20	0.18	0.36	0.56	0.89	1.25	1.66	3.35	1.60	2.09
191-13-b	0.24	0.21	0.38	0.62	1.12					
	thickness of spirotheca									
191-11-a	?	.30?	.050	.080	.120	.140	.120			
191-13-b	.025	.030	.050	.090	.115					
	tunnel angles									
191-11-a		18	25	31	36	27				
	number of septa									
191-13-b		11	19	21	29?					

larger shell size, thicker spirotheca, much inflated median portion of the shell of the former.

The specimen somewhat resembles *Triticites paraschwageriniformis* Rosovskaya, but differs from the latter in that the septal fluting of the former extend more to the inner parts of the axial profile, and more distinct chomata, and thicker spirotheca prevails in the former, and that the septa of the latter are rather similar with those of the genera *Pseudoschwagerina* and *Paraschwagerina*.

The present species differs from *Pseudofusulina sokensis* Rauser-Cernoussova in having weaker septal fluting, more regular septal loops, and smaller proloculus of the former.

Repository : - IGPS cat. no. 78832, 78838, loc. no. 191-11-a, 191-13-b.

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PLATE 29

(All from the Permian Shingai Formation. Coll. Ishizaki)

Figs. 1, 2. *Triticites simplex* (Schellwien). (p. 110), 1–Axial section, ×14. 2–Slightly oblique axial section, ×14. IGPS coll. cat. no. 78831, 78832, loc. no. 191–3–c, 191–11–c.

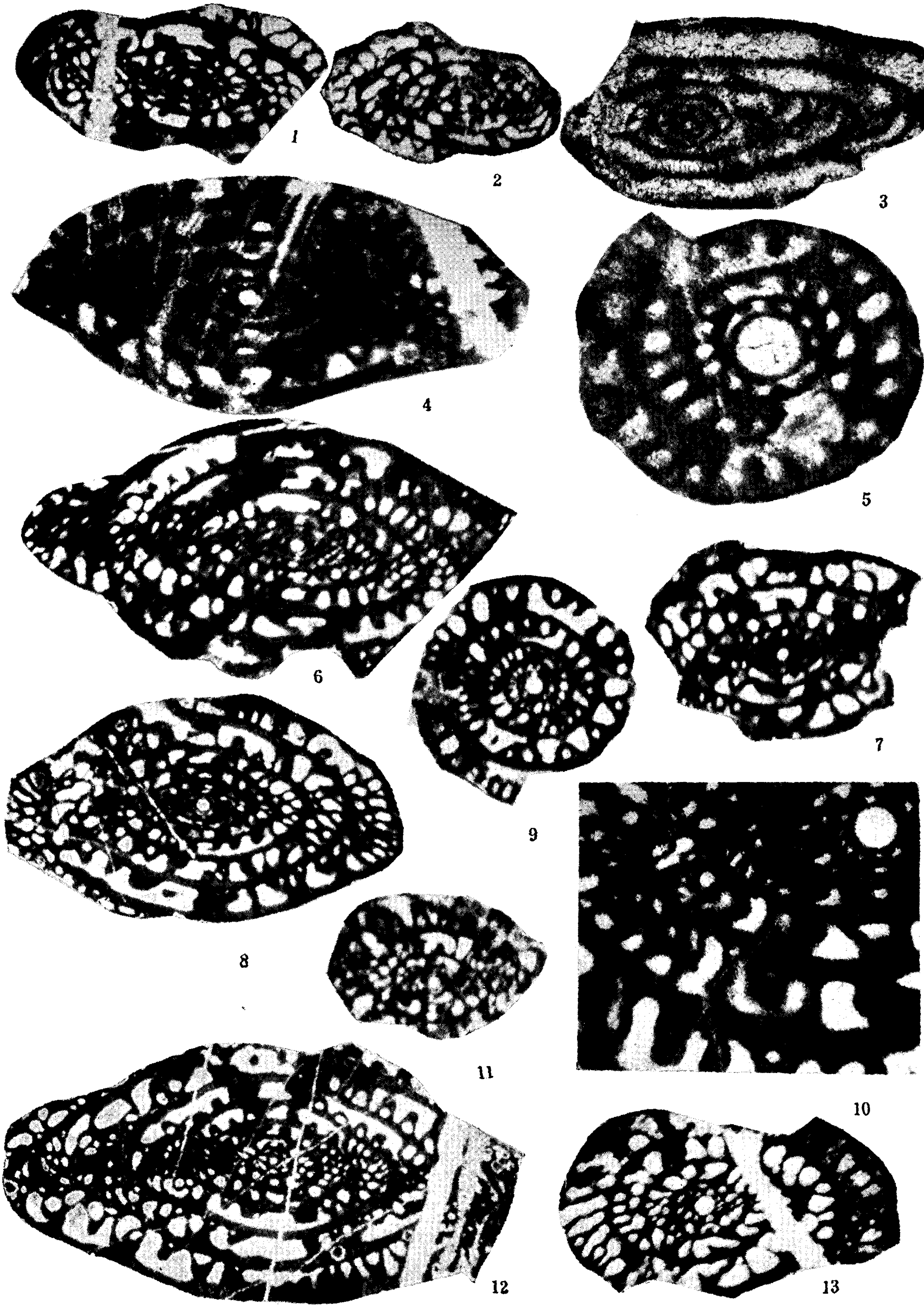
Fig. 3. *Schubertella kingi* Dunbar and Skinner. (p. 109). 3–Axial section, ×50. IGPS coll. cat. no. 78833. loc. no. 191–14–c.

Figs. 4, 5. *Schwagerina* cfr. *stabilis* (Rauser-Cernoussova). (p. 114). 4–Axial section, ×30. 5–Sagittal section, ×55. IGPS coll. cat. no. 78834, 78833. loc. no. 191–5–a, 191–14–c.

Figs. 6–10. *Schwagerina krotowi* (Schellwien). (p. 113). 6–8–Axial section, ×14. 9–Sagittal section, ×14. 10–Part of axial section showing the spirothecal structure; three layers seen, ×30. IGPS coll. cat. no. 78835, 78836, 78836, 78836, 78837, loc. no. 191–4–b, 191–2–b, 191–2–a, 191–2–c, 191–12–a.

Fig. 11. *Schwagerina* cfr. *munaniensis* Dunbar and Newell. (p. 111). Fragmental axial section, ×14. IGPS coll. cat. no. 78838. loc. no. 191–13–a.

Figs. 12, 13. *Schwagerina magna* (Rosovskaya). (p. 116). 12–Axial section, ×14. 13–Oblique sagittal section, ×14. IGPS coll. cat. no. 78832, 78838, loc. no. 191–11–a, 191–13–b.



Kumagai photo.